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A Situation Report

RACE 15B

Stem Rust of Wheat

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RACE 15B -- STEM RUST OF WHEAT

THE 1954 CROP of durum or macaroni wheat in the United States has been heavily injured by race 15B, the most virulent -- and most widespread -- stem rust of wheat ever found in North America. Losses this year in the durum-growing areas of the Dakotas and Minnesota amounted to about 75 percent. Last year's losses reached 65 percent or higher.

Practically no durum wheat is in storage, and seed for next season is scarce and selling at premium prices.

Durum wheat is used to make macaroni, spaghetti, and similar products, which are known collectively to people of Latin background as pasta, or pastes. Hard red winter and hard red spring wheats can be used to make these products, but the resulting pastes are not so acceptable to the housewife or to the edible paste industry.

Macaroni and spaghetti are being imported because quotas prevent entry into the United States of durum wheat and semolina, the refined middlings from which these pastes are made.

Race 15B also caused heavy losses among the bread wheats. Estimated yield reduction of bread wheats in 1954, mostly in the spring wheat areas, is placed at about 25 percent, though part of this was undoubtedly owing to drought and hot weather.

To overcome the destructive effects of race 15B, plant scientists of the Department, many States, and other countries are developing strains of durum and bread wheats that are resistant to it. Two varieties of resistant bread wheats are now in production, and favorable results are expected from at least two and possibly three new durum selections.

CHECKMATING 15B

RACE 15B was first found on a barberry bush in Webster County, Iowa, in 1939. Certain species of barberry have long been known to serve as intermediate hosts for stem rusts of wheat. New races of rust evolve on barberry bushes, making constant difficulties for those who are trying to maintain rust-resistant grains. In a special study made in 1948, 43 different races of stem rust were isolated from a Pennsylvania wheatfield bordered with barberry. Studies over a period of years show that 10 times as many races of rust occur on or near barberry as on grains and grasses in barberry-free areas. By 1948, race 15B had been found near barberry bushes in Illinois, Ohio, Pennsylvania, Michigan, and Virginia.

New races of rust are always potentially dangerous, and testing of commercial wheats for sources of resistance to 15B began immediately after its discovery in 1939. This work was done by the Department in cooperation with the University of Minnesota and the Dominion Rust Laboratory at Winnipeg, Canada. Many North American varieties and strains of wheat were inoculated with this rust under controlled greenhouse conditions. Not one was resistant to it. Tests continued until it was established beyond a doubt that every commercial variety of wheat then grown in the United States and Canada was susceptible. Work was begun on some additional wheat lines, particularly those from Kenya colony and protectorate (British East Africa), to determine their resistance to 15B. From 1939 to 1950 race 15B remained close to the barberries, local in occurrence, and generally rather quiescent.

Then, in 1950, this potentially dangerous race of rust became independent of the barberry as a host and spread to the wheatfields. It multiplied in the South (in Texas and northern Mexico) and was spread northward by the prevailing south winds to attack the bread basket of the Nation. The winter wheats of the Middle West, though susceptible to this rust, were too far advanced in 1950 when stem rust struck to be greatly damaged. But enough plants were infected to furnish other spores that could hedgehop and soar on the upper wind currents toward the north. The hard red spring wheats of the northern tier of States were not very hard hit, because they matured early that year. But the durums ripen 10 days to 2 weeks later, giving the rust an opportunity to propagate another generation of spores to fall upon these wheats. More than 20 percent of the durum crop was lost.

Race 15B, which had lurked among the barberries for 11 years, was on a rampage. Its spores became more numerous, rising to 27 percent of the stem rust samples taken from fields. The search was intensified for a wheat that could resist this windblown menace. Researchers turned to the Department's world collection of wheat stocks, which number more than 13,500 strains and varieties, to find resistant germ plasm. Work continued in Minnesota and Canada and began at the Agricultural Research Center, Beltsville, Md., in Idaho, Indiana, Kansas, North Dakota, South Dakota, Texas, Wisconsin, Puerto Rico, and the Virgin Islands. Cooperation was established with plant pathologists and wheat breeders in Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, and the Union of South Africa to test grains from the world collection under their conditions. The South American countries, where 15B was known or thought to exist, tested about 1,000 kinds. The entire collection of 13,500 kinds was screened in Mexico where the work was conducted in cooperation with the Rockefeller Foundation and the Mexican Ministry of Agriculture and Livestock.

There was a respite from attacks of 15B in 1951, but research continued in the various States and national centers.

In 1952 it struck again. Race 15B reached 58 percent of the races identified. The disease spread into 29 States, reaching from Mexico to Canada and from Maine to Montana. Race 15B was definitely established, and

the outlook was threatening. The disease caused a combined loss of $16.8 million to bread and macaroni wheats. While this was less than the $20 million loss in durums during 1950, it demonstrated that this stem rust carried the seeds of disaster. Research workers in Australia, Boliva, Egypt, Kenya, Nicaragua, Paraguay, Spain, Turkey, and Uruguay were asked to cooperate in finding resistant wheats. Each country tested about 100 of the more promising strains.

Race 15B hit the durum wheat hard in 1953, causing a loss of at least 65 percent of the crop. It hit even harder in 1954: according to the November crop report, durum production was nearly 8 million bushels, compared to a 1943-52 average of 35.5 million bushels a year -- a reduction of 77.5 percent in production and more than 60 percent in average yield per acre harvested.

Conditions were ideal during these two years for a widespread and damaging epidemic. Rust that developed early in Mexico, Texas, and Oklahoma spread north into Kansas and Nebraska. A large acreage of winter wheat in western Kansas, Nebraska, and South Dakota, because of the drought in the fall, did not begin growth until spring. The rust attacked the succulent growth with great vigor. There was a rapid buildup of inoculum in these areas, which was carried north at critical times on the prevailing south wind. This race of rust spread until it constituted 63 percent of the races identified. Excessive moisture and cold weather delayed the sowing of spring wheat in North Dakota, South Dakota, and Minnesota, and the wheat was exposed to large amounts of inoculum during its most susceptible period of growth. Ideal conditions of moisture and temperature prevailed for rust development in both of these years, and the toll was enormous. Not only were the durums almost wiped out, but there was a 25-percent loss of bread wheats in 1953 and about the same in 1954, most of it in the spring wheat areas. Part of it was attributable to 15B. This represented a greater volume of damage than that to the durum industry.

Two bread wheats have been produced that are resistant to 15B and many other races of rust. Selkirk, developed in Canada, and Willett, produced cooperatively by the U. S. Department of Agriculture and the University of Minnesota, have usually had no more than 25 percent of rust infection, even in the face of heavy and virulent invasion by spores of 15B. These varieties are expected to be generally available for seed in 1955. No commercially suitable rust-resistant durum wheat is yet ready for release. The research situation is hopeful, but more time is required to put a satisfactory wheat into the hands of durum growers.

The routine of research is complex and takes time. It is a relatively simple matter to plant a sample of wheat in a greenhouse and expose it, under controlled conditions, to various races of rust. But this is only the beginning. The wheat must then be exposed to rust under field conditions to see how it behaves. This may be necessary over a period of years in a given geographic location, in order to take in an average range of climatic conditions at that point. And, this must be done at many different places.

A wheat may be found that resists race 15B under greenhouse and field conditions. It is not, unfortunately, of a strain or variety that is commercially acceptable. It must then be crossed with wheats that are acceptable. The progenies of various crosses must be selected for five or six generations, followed by 3 or more years of testing. The resulting wheat must be resistant not only to race 15B but also to other prevalent and potentially dangerous races of rust. It must have stiff straw so it will not lodge. It should be able to endure drought and high temperature if it is a spring wheat and low temperature if it is a winter wheat. It must be resistant to insect pests such as the wheat stem sawfly. It has to be a good yielder so it can be grown profitably. Field tests must be made to demonstrate all these points, and arrangements must be made for the wheat to face an epidemic of rust in each test, whether or not nature arranges one. The grain must have good appearance, weight, and protein content. And finally it must mill well and bake well.

No one should be surprised, in the face of these difficulties, that at least 8 years is required to produce an acceptable variety of wheat. Even taking into account the skill of plant geneticists, who can shuffle genes into almost any desirable combination, the job is a long one.

When a satisfactory variety is achieved, there remains the question of increasing the seed. This is done by crop improvement associations, cooperating with State experiment stations, which furnish the foundation seed. It takes 2 years to grow enough seed for the first commercial release. The seed is distributed to selected seed growers by crop improvement associations and soon becomes generally available.

THE OUTLOOK

SEVERAL WHEATS of foreign origin have been found in the course of research to have the necessary degree of resistance to race 15B. They are commercially unacceptable in the United States, but their capacity to resist stem rust is being bred into high-quality varieties.

Officials of the Field Crops Research Branch are confident that within a very few seasons a good macaroni wheat will be available that can resist 15B.

Breeding for resistance, earliness, milling and baking qualities is, however, only one of the steps to be taken. Barberry eradication measures must be carried to completion in every important grain-growing area. Growers should use cultural practices that will increase the probability of an early, healthy crop. Further research is needed on the use of fungicides to control stem rust.

There are many problems in the great chess game between the scientists and the wheat rusts, but there are hopeful signs too. One is that certain varieties of wheat in the world collection have been proved resistant not merely to one race of rust but to many. Some of the Kenya strains are resistant to as many as 35 races. Transferring resistant genes to desirable varieties is one of the aims of plant breeders. This has been the goal for 50 years, and up to the epidemic of 1950 the work had been very successful -- not for many years had rust made such inroads into the wheat supply.

Research workers are attacking the rust problem in at least 9 States and 2 possessions of the United States, and in 17 other countries.

THE BACKGROUND

RUSTS OF SMALL GRAIN are an old story in the United States. Eight distinct species and subspecies of rust fungi attack wheat, oats, barley, and rye. Wheat is subject to stem rust, leaf rust, and stripe rust, in that order of importance in North America.

Stem rust is characterized by pustules that break through the surface of the stem, absorb the moisture and nutrients that are needed to develop the wheat kernels, and permit the loss of moisture from the plant. As a result, the kernels are shriveled and undernourished. Some are so light and chaffy that they are blown out with the chaff in the course of threshing. The remaining grains may never develop beyond one-half to two-thirds of their normal size and are fit only for animal feed. The rusted stem turns brown, becomes dry and brittle, and soon breaks over.

The red spores of the rust that spread the disease to wheat are about one-thousandth of an inch long. A single rust pustule may produce 350,000 spores -- hence the disease can spread very rapidly under favorable conditions. Starting in Texas or northern Mexico, where the rust has overwintered on susceptible grains and grasses, the spores are carried northward on prevailing winds. They may be carried in short hops, about a State at a time, following the development of the wheat crop from the southern to the northern tier of States -- and on into Canada. Or, they may rise on a high-level wind to 10,000 feet altitude or more, and ride in one nonstop flight from Mexico to Canada. Or they may blanket the wheatfields by both local and nonstop flights.

The spores are incredibly numerous. A heavy rust epidemic on the 4 million acres of wheat in South Dakota could produce about 2 sextillion spores -- the figure is 2 followed by 21 zeros. If only 1 in 10,000 of these spores were carried into North Dakota, there would still be enough to provide 4 spores for every wheat plant on 10.6 million acres in the State.

Spores blown southward in late summer and early fall can attack volunteer and early-sown wheat, and certain grasses. These plants provide rust inoculum for fall-sown wheat in the south, where the rust may live over winter.

Both stem and leaf rust of wheat were recognized as destructive diseases in the United States long before the 20th century. Laws were enacted against the barberry before the American Revolution, and many of these bushes were destroyed for stem rust control prior to 1900. Experiments in spraying with fungicides convinced B. T. Galloway of the U. S. Department of Agriculture about 1890 that the disease could be controlled. But this method has not yet proved economically feasible. It was better to find resistant varieties. By 1900, M. A. Carleton of the Department had introduced resistant wheats from Russia and Italy. Certain of these wheats that could not be used commercially furnished rust-resistant parents for wheat hybrids that could be grown, marketed, milled, and used satisfactorily. As various races of rust have invaded the wheatfields from time to time in subsequent years, hybridization of wheat to create resistant varieties made it generally possible to keep ahead of the rusts until 1950. Beginning in 1950, race 15B forged ahead.

There are about 275 known races and biotypes of stem rust in the world. Among those that caused most trouble in the United States for 10 years or more before the advent of 15B are races 17, 38, and 56. In 1953, however, 21 of the 35 States having stem rusts had a preponderance of race 15B.

Because the common European barberry provides a local source of stem rust inoculum and a breeding ground for old and new races of rust, a Federal-State program of barberry eradication was started in 1918. It operates in 18 of the principal grain-growing States where barberry is a problem -- Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Montana, Nebraska, North Dakota, Ohio, Pennsylvania, South Dakota, Virginia, Washington, West Virginia, Wisconsin, and Wyoming.

From the inception of the program in 1918 through 1953, more than 462 million barberry bushes were destroyed on 147,000 properties. Survey and eradication work was completed on 956,054 square miles in a total problem area of 1,033,457 square miles. During 1953, 11.5 million barberry bushes were destroyed by the application of ammonium sulfamate to the cut-off canes, or by foliage and dormant sprays of hormone-type chemicals.

The major job of survey and eradication has been completed in Indiana, North Dakota, Montana, South Dakota, and Wyoming, and the States have taken over maintenance of the program. So much progress has been made in Illinois, Missouri, and Nebraska that Federal participation has been materially reduced. Considerable numbers of bushes are being destroyed each year in Iowa, Minnesota, Michigan, Washington, and Wisconsin, but a big eradication job remains in Ohio, Pennsylvania, Virginia, and West Virginia. In spite of recent heavy damage, average annual losses from rust have been reduced by more than 50 percent in the principal grain States of the Middle West. Virginia farmers reported a 68-percent increase in wheat production following local barberry eradication. This program and the use of rust-resistant varieties have provided stem-rust control worth hundreds of millions of dollars.

Ordinary barberry bushes do not become infected with stem rust in the States south of a line marked by the southern borders of Utah, Colorado, Kansas, Missouri, Kentucky, and Virginia. Spores of the black stage of stem rust do not germinate readily in spring unless they have been frozen during the winter. Hence barberry bushes are not destroyed in such grain-producing States as Oklahoma and Texas. The problem in these States is with the red spore stage, which persists throughout the year on susceptible grains and grasses.

An organized cooperative Federal-State survey and eradication program was started this fall in Kansas. Localized barberry eradication programs are also conducted in grain-producing areas of Idaho, New York, and Oregon, in cooperation with State, community, and farm groups.